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ABSTRACT

This publication describes the major fields of engineering in relation to career opportunities, in the hopes of attracting more minority students to these fields. Salary expectations are outlined, and programs designed to prepare more minority engineers are detailed. There is a listing of organizations which provide information on careers in engineering. (WI)

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MINORITIES IN ENGINEERING

by Trienne Glover*

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For a variety of reasons, minority groups are grossly underrepresented in the field of engineering. In 1974, less than 3% of the engineers in the U.S. were members of the four largest minority groups (Black Americans, Mexican Americans, Native American Indians, and Puerto Ricans), although these groups total nearly 17% of the country's population. Only 1.8% of the engineering degrees awarded in 1974 went to blacks, who as a group comprise 11.1% of the population. Spanish surnamed students made up 1.5% of the engineering graduates, but 4.4% of the population. Figures for Native Americans were even lower.[1]

The engineering field should hold great appeal for minority students, for engineers create. They are inventors, designers, developers whose works improve our lives in countless ways every day. They create products for better health, better housing, sanitation, transportation, and better pollution control. To accomplish these things, en-

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[1]Committee on Minorities in Engineering, Building Effective Minority Programs in Engineering Education (Washington, D.C., National Academy of Sciences, 1975) p. 1.

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gineers design life saving machines and artificial organs. They develop electric power, water supply, and waste disposal systems. They design industrial machinery, equipment used to manufacture goods, and heating, air-conditioning, and ventilation equipment. They develop scientific equipment to probe outer space and the ocean depths, and design, plan, and supervise the construction of buildings, highways, and rapid transit systems. They design and develop automobiles, television sets, refrigerators, and systems for control and automation of manufacturing, business, and management processes.[2]

If you enjoy math, have a logical mind, like problem solving and challenges, then engineering may be a good career choice for you. Strong preparation in high school math and science is necessary, as is a good background in English (an engineer must be able to communicate well). An engineer should be able to work closely and well with others, be creative, and have a mind for details. Though a bachelor's degree in engineering, or in some cases in science or math, is a prerequisite for some beginning jobs in engineering, increasingly graduate training is required. Specialties such as nuclear engineering, for example, often are taught only at the graduate level. About 280 colleges and universities offer the bachelor's degree in engineering. Most of these schools offer degrees in the larger branches of engineering, but the professional specialties are taught in only a few schools. Therefore, students who want specialized training should investigate colleges' curricula before making a choice of which school to attend.

The typical 4-year curriculum requires during the first 2 years, study of the basic sciences -- mathematics, physics, chemistry, introductory engineering -- and the humanities, social sciences, and English. Engineering courses dominate the remaining two years' study. Some engineering programs require 5 years to complete. A number of colleges and universities offer 5-year master's degree programs. Others have formal arrangements with liberal arts colleges, allowing a student to spend 3 years in liberal arts and 2 years in engineering. The student receives a bachelor's degree from each school. Also some schools have 5 or 6 year cooperative education programs where students coordinate classroom study and practical work experience.[3]

Salaries

Starting salaries for engineering graduates are very good, ranging from $12,500 for engineers in computer science to $16,776 for graduates in petroleum engineering. With offers like these, well over half of the 1976 graduates in engineering went directly to work. Nearly another fourth went on to graduate study, while the remainder went into military service or had not yet decided what they wanted to do at the time they were surveyed.[4]

Bureau of Labor Statistics
Salary Ranges for Experienced Engineers

	1976 (9-11 yrs. experience)
B.S.	$ 20,800
M.S.	22,650
Ph.D.	25,500

[2]Occupational Outlook for College Graduates, 1976 - 77 ed., Bulletin 1878 (Washington, D.C., Bureau of Labor Statistics, 1977), p. 111.

[3]Ibid., p. 112.

[4]From Salary Survey, The College Placement Council, Inc., 1976

Major Fields of Engineering[5]

AEROSPACE ENGINEERING

Aerospace engineers design, develop, and test air and space craft and aerospace products. They generally specialize in an area of work such as structural design, navigational guidance and control, instrumentation and communication, or production methods, or they may specialize in a type of aerospace product such as passenger planes, launch vehicles, satellites, manned space capsules, or landing modules. Approximately 52,000 aerospace engineers were employed in 1974, most of them in the aircraft and parts industry and in Federal agencies like the National Aeronautics and Space Administration and the Department of Defense. Others were employed by commercial airlines, consulting firms, and colleges and universities. Although defense and space expenditures probably will not reach again their peak levels of the 1960's, additional aerospace engineers will be needed to fill openings caused by growth in the aerospace industry and by deaths, retirements, and transfers.

AGRICULTURAL ENGINEERING

Agricultural engineers design machinery, equipment, and structures for farms, for food and feed processing plants, and for conservation and management of soil and water resources. They may work in research and development, production, sales, or management. Manufacturers of farm equipment and supplies employed most of the approximately 12,000 agricultural engineers employed in 1974. Others worked for engineering consultants who supply services to farmers and farm industries, the Department of Agriculture's Soil Conservation Service and Agricultural Research Service, colleges and universities, state and local governments, or as independent consultants. The demand for agricultural engineers is expected to exceed the average occupation demand through the mid-1980's because of increased need for agricultural products, modernization of farm operations, greater conservation of resources, and the search for more efficient use of agricultural products and wastes from industry.

BIOMEDICAL ENGINEERING

Biomedical engineers research, design, and develop medical instruments and life-maintenance devices, including artificial organs. Some research "engineering aspects of the biological systems of man and animals. . . .Other biomedical engineers adapt computers to medical science, and design and build systems to modernize laboratory, hospital, and clinical procedures. Most engineers in this field require sound background in one of the major engineering disciplines (mechanical, electrical or chemical) in addition to specialized biomedical training." In 1974, 3,000 biomedical engineers taught and conducted research at colleges and universities or worked for the Federal government--NASA in particular, in state agencies, and in private industry. Though employment in biomedical engineering is expected to increase faster than the average for all occupations through 1985, the actual number of openings will be small.

[5]Occupational Outlook. . ., pp. 113 - 122.

CERAMIC ENGINEERING

Ceramic engineers work with all non-metallic, inorganic materials which are processed with high heat. They develop glassware, heat resisting materials for missile nose cones, electronic components and materials used in medical devices and nuclear reactors, porcelain and china dinnerware, electrical insulators, refractory coatings for metals, abrasives, cements, and fuel elements for atomic energy. The 12,000 ceramic engineers employed in 1974, worked in stone, clay, and glass industries and industries that produce or use ceramic products such as iron and steel, electrical equipment, aerospace, and chemical industries. Some ceramic engineers were employed by colleges and universities, independent research organizations, and the Federal government. Employment for ceramic engineers looks good through the mid-1980's because of the need for ceramic products in pollution control, energy conservation, defense, electronics, and medical science.

CHEMICAL ENGINEERING

Chemical engineers design equipment and chemical plants, and determine test methods of manufacturing chemical products. Since chemical engineers work across several fields, they must have a knowledge of chemistry, physics, and mechanical and electrical engineering. The 50,000 chemical engineers employed in 1974 worked in the petroleum, chemical, and other manufacturing industries; in government agencies; colleges and universities; for research institutes and engineering firms; or as independent consultants. The demand for chemical engineers is expected to be high through 1985 because of industrial expansion, increased concern with environmental protection, the development and processing of synthetic food, the design and development of nuclear reactors, and new chemicals needed to produce consumer goods.

CIVIL ENGINEERING

"Civil engineers design and supervise the construction of roads, harbors, airports, tunnels, bridges, water supply and sewage systems, and buildings. Major specialities within civil engineering are structural, hydraulic, environmental (sanitary), transportation (including highways and railways), geotechnical and soil mechanics. Many civil engineers are in supervisory or administrative positions ranging from site supervisor of a construction project or city engineer to top-level executive. Others teach in colleges and universities or work as consultants." The nearly 170,000 civil engineers employed in 1974 worked in all parts of the country, usually in or near major industrial and commercial centers or at construction sites, some which were in remote areas, in foreign countries, or involved moving from place to place to work on different projects. Growing needs for housing, buildings, power plants, and transportation systems, and problems of pollution and energy generation and conservation are expected to keep the demand for civil engineers well above the average demand for all occupations.

ELECTRICAL ENGINEERING

Electrical engineers design and develop electrical and electronic equipment such as electric motors and generators, communications equipment, heart pacers, pollution meas-

suring instrumentation, radar, computers, lasers, missile guidance systems, and electrical appliances. They also supervise the manufacture of these products and design and operate facilities for generating and distributing electric power. Some electrical engineers work in research, development and design; some are administrators or managers; others work in manufacturing, in technical sales, or teach college courses. There were nearly 290,000 electrical engineers employed in 1974, making electrical engineering the largest branch of the engineering profession. These electrical engineers were employed mainly by manufacturers of electrical and electronic equipment, aircraft and parts, business machines, and professional and scientific equipment. Telephone, telegraph, and electric light and power companies employed many more. The need for computers, communications and electric power generating equipment, and military electronics will result in the continuing above average need for electrical engineers.

INDUSTRIAL ENGINEERING

Industrial engineers are concerned with the efficient use of personnel, machines, and materials in the production process. "They are more concerned with people and methods of business organization, than are engineers in other specialities who are generally concerned more with particular products or processes. . .Industrial engineers design systems for data processing and apply operations research techniques to organizational, production and related problems. They also develop management control systems to aid in financial planning and cost analysis, design production planning and control systems to coordinate activities and control product quality, and design or improve systems for the physical distribution of goods and services. Other activities include plant location surveys, where they must consider sources of raw materials, transportation, and taxes, and the development of wage and salary administration concepts and job evaluation programs." Most of the 180,000 industrial engineers employed in 1974 worked in manufacturing industries; some were employed by insurance companies, banks, construction and mining firms, and public utilities. Others worked for hospitals, retail organizations, large business firms, government agencies and in consulting and college teaching. Expansion of industry and automated processes and increased interest in reducing costs and increasing productivity through scientific management and safety engineering should keep the need for industrial engineers above the average occupational demand through 1985.

MECHANICAL ENGINEERING

Mechanical engineers design and develop machines that produce and use power: internal combustion engines, steam and gas turbines, jet and rocket engines, nuclear reactors, refrigeration and air-conditioning equipment, elevators, machine tools, printing presses, steel rolling mills, etc. Mechanical engineers design, conduct research on, and test machines. Some mechanical engineers are administrators, maintenance workers, technical salesmen, and production managers. Others teach in colleges and universities or work as consultants. The 185,000 mechanical engineers employed in 1974 worked mainly in primary and fabricated metals, machinery, transportation equipment, and electrical equipment industries. Industrial growth and pollution reduction and power needs are expected to result in higher than average demand for mechanical engineers through the mid-1980's

METALLURGICAL ENGINEERING

Metallurgical engineers (often called materials engineers) work with the processing and converting of metals into useful products. "Extractive metallurgists are concerned with extracting metals from ores, and refining and alloying them to obtain useful metal. Physical metallurgists deal with the nature, structure, and physical properties of metals and their alloys, and with methods of converting refined metals into final products. Mechanical metallurgists develop methods to work and shape metals such as casting, forging, rolling, and drawing." The 17,000 metallurgical and materials engineers employed in 1974 worked primarily for the iron, steel, and nonferrous metals industries. Others worked for machinery, electric equipment, aircraft and parts, and mining industries; government agencies and colleges and universities. The increase in demand for metallurgical engineers through 1985 is expected to be about equal to the average for all occupations. As high-grade ore deposits are used up, metallurgical engineers will be needed to develop ways of recycling solid waste materials and processing low-grade ores now regarded as unprofitable to mine.

MINE ENGINEERING

Mining engineers locate and plan the extraction and preparation of minerals. They design the layouts of mines, supervise the construction of mine shafts and tunnels, devise methods for transporting minerals to processing plants, and insure the efficient and safe operation of mines. They provide for adequate ventilation, water, power, communication, and equipment maintenance. Some mining engineers work in conjunction with geologists and metallurgical engineers to locate and appraise ore deposits; some develop new mining equipment and improved processing methods. Most of the 5,000 mining engineers working in 1974 were with the mining industry, working at the location of mineral deposits, often near small communities. Some worked in colleges and universities, government agencies, in sales or as independent consultants. Increased demand for coal, better mining systems, improved enforcement of mine health and safety regulations, exploration for minerals, and efficient methods for mining low-grade ores will keep the demand for mining engineers high through the next decade.

PETROLEUM ENGINEERING

Petroleum engineers are concerned with drilling for and producing oil and gas by the most efficient means, "since only a small proportion of the oil and gas in a reservoir will flow out under natural forces." Petroleum engineers continuously work to devise better means of artificial recovery of the precious fuels. The 12,000 petroleum engineers employed in 1974 worked mainly for oil companies, drilling equipment and supply companies, government, engineering consultant firms, and banks and other financial institutions which need to know the economic value of oil and gas properties.

Engineering Education

Obtaining an engineering degree often takes longer than obtaining a liberal arts or other bachelor's degree, since many engineering programs take five years to complete. However, the employment opportunities for the engineer are more than worth the extra study. In 1974, engineering, with 1.1 million persons employed in the field, was second only to teaching as the largest occupation. More than 330,000 engineers were employed in such nonmanufacturing industries as construction, public utilities, engineering and architectural services, and business and management consulting services. 150,000 engineers worked for Federal, State, and local governments, and 43,000 were employed in research and teaching in colleges and universities.[6] One half of the industrial job offers in 1976 went to engineering graduates, who made up only 6% of the B.S. degree recipients. In 1977, 47% of the job offers being made were for engineers.[7] Engineers who excel in their jobs often become administrators and executives. Some engineers return to school for the MBA (Master of Business Administration) degree to improve their advancement opportunities; others obtain law degrees and become patent attorneys. Many engineers have moved not only into management but also into sales. Half of the upper level employees in the federal government have technical backgrounds. In later years, for members of minority groups to advance to positions of management in government agencies and industry where a knowledge of the technical is necessary, they will have to get their basic technical backgrounds now.

Programs to Prepare More Minority Engineers

A national campaign has been launched by the Committee on Minorities in Engineering (of the Assembly of Engineering, National Research Council) to increase tenfold the representation of the four main minority groups in the field of engineering. In its recent publication, Building Effective Minority Programs in Engineering Education, the Committee states the following:

> The employment of engineers has expanded by more than 80% since 1950, mainly because technology has burgeoned in the past 25 years. . .[However], few minority youths have been either motivated or trained to become engineers. . . .Historic patterns of discrimination have frustrated or discouraged minority students from seeking engineering degrees. . .What's more, as the most economically and educationally disadvantaged, these four minorities often lack the rigorous academic preparation for engineering school and the family or peer models to emulate in choosing a career.

One means of attacking the inequity in the numbers of minority engineers and the academic difficulties often experienced by minority students is to start early in the lives of minority youth to introduce them to the field of engineering -- to let them know at an early age that a career in engineering is not a dream but an attainable goal, and to develop their skills in mathematics and science so that they will be prepared to do college level

[6]Ibid., p. 111.

[7]Committee on Minorities in Engineering Career Guidance Aid, Unpublished, Ann Goode, ed., 1977.

work when they finish high school. The National Advisory Council on Minorities in Engineering (NACME) is working toward the goals of strengthening the sciences and mathematics in pre-college education and increasing the participation of industrial companies in local school activities. Edward R. Kane, Chairman of NACME, has proposed that "corporate members take the initiative in communities where they operate to organize, build, and support local programs to bring engineering 'home' to youths and parents. . . Kane urged NACME members to serve as catalysts in their communities to get programs started that will encourage young people, starting at the junior high school level, to prepare for an engineering education." Lewis Branscomb, Vice President of IBM, warns, "the goal of parity for minority youths can turn out to be a 'cruel joke' if as students they are unable to compete academically in college."[8]

There are several pre-college programs in operation across the country to attract and prepare engineering students. For example, the American Society of Civil Engineers holds summer institutes for junior and senior high school students from many states and the District of Columbia. The Philadelphia Regional Introduction for Minorities in Engineering (PRIME) conducts two hours of activities during school time each week at junior and senior high schools in the Greater Philadelphia area. These and other pre-college programs are coordinated by the Committee on Minorities in Engineering.[9]

The Committee reports that "A number of consortia have been formed in various sections of the nation with the objective of coordinating and expanding collective efforts in the areas of early motivation, guidance, recruitment at the pre-college level, and retention after matriculation. These consortia are usually assembled by [and consist of] engineering colleges, industry, professional groups, and minority organizations."[10]

Many engineering colleges work directly with high schools to inform students of the advantages of careers in engineering and to build the math and science skills of the interested students. The Engineers' Council for Professional Development sponsors a large number of summer programs under its Minority Introduction to Engineering (MITE) program. The MITE summer sessions expose interested high school students to educational and career opportunities in engineering. Some colleges hold summer programs or Saturday programs for high school students with interest in engineering. The Committee on Minorities in Engineering notes that ". . .while special summer or Saturday programs have merit, a difficulty exists in establishing preparatory programs as a regular part of the high school curriculum. Some colleges are working closely with public school administrators and faculty to offer special courses which will improve math and science skills. In a few cities efforts are being initiated to create pre-engineering technology high schools."[11]

Methods in current use to increase the number of minority students in engineering include high school visitations, mailing of letters and brochures on engineering studies and careers, parental involvement, stressing of engineering within larger minority recruitment efforts, use of engineering alumni as recruiters, use of high school science and math teachers as recruiters, transfering students from community colleges, holding an engineering school open house, and touring high schools and community colleges with a mobile van set up to promote interest in studying engineering. Better coordination and more

[8]Ann Goode, ed., "Minorities in Engineering Newsletter," Fall 1976, p. 1.

[9]Ibid., p. 2.

[10]Building Effective Minority Programs., p. 12.

[11]Ibid., p. 14.

widespread implementation of these methods are needed, however.[12]

There are a number of programs in effect to ease the academic transition of minority students into the rigorous study of engineering. Pre-freshman year summer programs, usually conducted for students who appear to be in need of academic assistance, are "designed to improve the opportunities for success of students previously identified, recruited, and admitted." Some colleges use these programs to further evaluate the potential of prospective students. 80% of the colleges surveyed by the Committee on Minorities in Engineering maintained some type of academic assistance program. In efforts to increase the quality and quantity of minority engineers, these schools provide tutoring in both course content and general skills building, curriculum adjustments such as reduced course load or stretching a course over a longer period of time, counseling, and the supporting of minority student organizations.[13]

The combined thrust of the college-level minority engineering programs appears quite successful when one looks at figures showing 2900 engineering graduates from the four main minority groups in 1973, but 5300 graduates in 1975. Today, there are as many as 75 predominantly white schools operating meaningful programs to assist minority students, says Percy Pierre, former Dean of Engineering at Howard University and Chairman of the Committee on Minorities in Engineering.[14] Schools with or without engineering departments can help alleviate the minority shortage of engineers by instituting pre-college projects and programs to interest high school students in careers in engineering and by forming cooperative arrangements with industry or other schools. Local people in industry or members of the local engineering society can come to campus to talk to students, make curriculum suggestions, talk to guidance counselors, and make presentations. Projects can be set up to familiarize parents with potentials of careers in engineering for their children.

The minority colleges are in an excellent position to increase the pool of minority engineers, since "Minority faculty and staff are on hand for advice and counseling as well as to serve as role models, spurring students to achieve excellence. The transitional problems from high school to college are reduced because the need to adjust to a predominantly white institution is not applicable. And students share common traditions, so there is no need for a special minority program."[15] The Committee on Minorities in Engineering has found that:

> By far the majority of Black engineers have attended six predominantly Black colleges of engineering. Only since 1973 have all the other engineering colleges granted degrees to Blacks in numbers comparable to those six colleges. The six are Howard University, North Carolina A&T, Prairie View A&M, Southern University, Tennesee State, and Tuskegee Institute. . . .these schools still represent 30% of all Black engineering freshmen. . .
>
> Although hampered by limited financial resources, these schools have responded to the nation's need for an increased minority engineering effort. However, recruiting for the predomi-

[2]Ibid., pp. 16 - 18.

[3]Ibid., pp. 24 - 26.

[4]Goode, p. 2.

[5]Building Effective Minority Programs, . . ., p. 32.

> nantly Black schools has proved as difficult as for the predominantly White schools. . .Retention is the primary problem facing these schools. Having pace-setting Black students in class often motivates other students to greater effort and achievement.[16]

If you are interested in a career in engineering and would like detailed information on a college's engineering program, write to that college for information and a catalogue. The college's financial aid office can provide information on financial assistance. The League of United Latin American Citizens National Education Service Centers (400 "I" Street, N.W., Suite 716, Washington, D.C. 20005) and the Advisory Council on Financial Aid to Students (Room 4682, ROB, 7th and D Streets, S.W., Washington, D.C. 20202) can also provide information about financial aid.

Cooperative education programs, industrial organization and foundation support, scholarships, stipends, tuition and fee waivers, loans, jobs, etc., are among the many means of financial assistance available to minority engineering students once they are accepted into engineering school.

If you are interested in starting a program to increase the number of minority engineers, some sources of funding for projects and programs in engineering are the National Science Foundation with its Minority Institutions Science Improvement Program; the Westinghouse Educational Foundation; the Wunsch Foundation, Inc; the Camille and Henry Dreyfus Foundation, Inc.; the Aifred P. Sloan Foundation; and the federal Energy Research and Development Administration, Division of University and Manpower Development Programs.

For information on programs already in effect to increase the number of minority engineering students or for ideas on starting new programs, contact the Committee on Minorities in Engineering, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418 (202/389-6417).

Information on Engineering

For additional information about various aspects of the engineering field and engineering as a career choice, the following organizations will be helpful:[17]

Alliance for Engineering in Medicine and Biology
3900 Wisconsin Avenue, N.W., Suite 300
Washington, D.C. 20016

American Ceramic Society
65 Ceramic Dr.
Columbus, Ohio 43214

[16]Ibid.

[17]Unpublished Career Guidance Aid, p. 2.

American Institute of Aeronautics and Astronautics, Inc.
1290 Avenue of the Americas
New York, New York 10019

American Institute of Chemical Engineers
345 East 47th Street
New York, New York 10017

American Institute of Mining, Metallurgical and Petroleum Engineers
345 47th Street
New York, New York 10017

American Nuclear Society
244 East Ogden Avenue
Hinsdale, Illinois 60521

American Society of Agricultural Engineers
420 Main Street
St. Joseph, Michigan 49085

American Society of Civil Engineers
345 East 47th Street
New York, New York 10017

The American Society of Mechanical Engineers
345 East 47th. Street
New York, New York 10017

ASPIRA of America, Inc.
22 East 54th Street
New York, New York 10022

Biomedical Engineering Society
P.O. Box 2399
Culver City, California 90230

California Consortium for Minorities in Engineering
California State University
Northridge, California 91324

Engineer's Council for Professional Development (ECPD)
345 East 47th Street
New York, New York 10017

Foundation for Medical Technology
Mt. Sinai Medical Center
100 Street, 5th Avenue
New York, New York 10029

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street
New York, New York 10017

Mexican American Engineering Society
P.O. Box 41
Plancentia, California 92670

Minority Engineering Education Effort
345 East 47th Street
New York, New York 10017

National Council of Engineering Examiners
P.O. Box 5000
Seneca, South Carolina 29678

National Institute of Ceramic Engineers
4055 North High Street
Columbus, Ohio 43214

National Society of Professional Engineers
2029 K Street, N.W.
Washington, D.C. 20006

Project Southwest
P.O. Box 175
Livermore, California 94550

Puerto Rican Engineer's and Scientists' Society, Inc.
c/o CHEMICO, One Penn Plaza
New York, New York 10001

SER Jobs for Progress, Inc., National Office
9841 Ariport Boulevard, Suite 1020
Los Angeles, California 90045

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15086

Society of Hispanic Professional Engineers
P.O. Box 48, Main Office
Los Angeles, California 90053

Society of Manufacturing Engineers
20501 Ford Road
Dearborn, Michigan 48128

Texas Alliance for Minorities in Engineering (TAME)
College of Engineering, Cockrell Hall
University of Texas at Austin
Austin, Texas 78712

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"Salary Survey," The College Placement Council, Inc. 1976.